Growth and Yield of Mango cv Golek in Java Over 25 Years

E.W.M. VERHEIJ
Department of Tropical Crop Science, Agricultural University, Wageningen.

Abstract

Trunk cross sections of selected 'Golek' clones increased almost linearly from the age of 5 to 25 years at the high rates of 90 cm^2 and 70 cm^2 per year for nucellar seedlings and grafted trees respectively. Yields were extremely low and erratic and did not seem to affect tree growth. The highest yield levels occasionally attained by individual trees amounted to 1 fruit per cm^2 trunk cross section.

The 2 best seedling trees were far superior to the rest and about as fruitful as the best clone; the latter attained an aggregate crop of 3320 fruit and a trunk size of 1560 cm^2, against average values of 1765 fruit and 1580 cm^2 for the other grafted clones. Differences between clones were large but not sufficiently consistent to substantiate them. The results suggest that a similar analysis over the full 45-year experimental period (!) and including the clones of other cultivars in the trial, could be very worthwhile.

Introduction

The mango collection at the Chukurgondang experimental farm near Pasuruan comprises about 200 cultivars: 72 from East Java, 64 from Central and West Java and 66 from other countries. The collection is unique because of the long period of observation (from 1941) and because tree growth has been recorded as well as yield. At the time several fruit tree collections were established by the Agricultural Extension Service (Terra, 1948), to test the suitability of different species and cultivars. Chukurgondang is situated in the centre of mango cultivation in East Java and the mango collection goes down to the clonal level in order to establish whether the tree population of a so-called cultivar is indeed uniform or not, and if not, whether clonal selection within the cultivar is worthwhile.

At Chukurgondang the original record books from 1941 are still in use. To find out whether a comprehensive analysis of this wealth of information might be worth the effort, such an analysis was carried out for the clones of a single cultivar, 'Golek', and over a 25-year period only. The results are presented in this paper.

Materials and Methods

Pitoyo et al (1982) gave a general description of Chukurgondang Station. The farm is about 50 m above sea level. The area has a monsoon climate with a prominent dry season: average rainfall (1960–1981) from May to November amounts to only 220 mm, against 1140 mm during the remaining five months.

The trees are planted at 14 m square and now form a closed stand. The soil is sandy and deep, infertile, and with low water retention. Mango growers in the area prefer somewhat better soils. There is no irrigation. The orchard is clean-cultivated; fertilizers and manure have been applied mainly in the early years. The staff list several pests and diseases which cause serious fruit losses in some years (Pitoyo et al, 1982):

mango hoppers, fruit flies, mealy bug, bats and birds, anthracnose and sooty mould. The trees are too big for effective crop protection.

The selected 'Golek' clones in Chukurgondang are listed in Table 1. They are identified by a number and have all been propagated from a mother tree collection in nearby Pasuruan.

Table 1
Number of trees of the 8 clonal selections of cv Golek,
year of planting and rootstock

Clone Number	31	33	35	133	177	195	229	255
Trees on 'Madu' stock, planted in 1941	2	2	2	2	2	2	2	2
Trees on 'Madu' stock, planted in 1956	—	—	3	—	—	—	—	—
Nucellar seedling trees, planted in 1956	—	—	—	—	—	—	19	—

In addition to the 'Golek' selections, the collection comprises somewhat smaller numbers of 'Madu', 'Arumanis' and 'Manalagi' trees; numerous other cultivars are represented by pairs of trees of one or two selections only.

Annual records for each tree include:

- trunk girth, for the grafted trees at 10 cm above and below the union and for the seedling trees at the same height as the scion measurement;
- tree height and tree spread in the E-W and N-S directions;
- number and weight of fruit.

For this paper only the trunk girth and number of fruit per tree have been analysed, over a 25-year period from planting. Girth was converted to trunk cross section ('basal area'), assuming a circular cross section. Basal area brings out differences in size between trees better than girth or diameter (Verheij, 1972); differences in tree weight are generally somewhat greater than differences in basal area.

The trees of each clone are planted side by side; this arrangement and the low tree numbers per clone precludes statistical analysis.

Results

Figure 1 depicts basal area growth and annual crop load for the three groups of 'Golek' trees listed in Table 1. As the trees grow older and bigger they can bear larger numbers of fruit. To be able to compare crop loads irrespective of tree size, the crop load has been expressed as the number of fruit per cm^2 basal area. Only crop loads exceeding 1 fruit per 8 cm^2 basal area are shown in Fig. 1.

The growth curves in Fig. 1 are rather straight. After a slight upswing in the first few years, the seedling trees grow at a rate of about 90 cm^2 per year against around 70 cm^2 for the grafted trees. Initially all trees planted in 1956 grow equally well, but after 5 years the superior vigour of the seedling trees becomes manifest.

The trees are extremely poor yielders. Clone 35 planted in 1956 comes out best, but even for this clone in half the years the crop is too light to be shown in Fig. 1. The seedling trees only produce a crop in excess of one fruit per 8 cm^2 basal area once in 25 years. It should be borne in mind that even a yield of one fruit per 2 cm^2 basal area is not at all high. In apples for instance, yields exceeding 1 kg/cm^2 trunk cross section are not uncommon (Verheij, 1972; Verheij and Verwer, 1972).

There is no indication in Fig. 1 of a relationship between yield and growth in the sense that in a fruitful year basal area growth is reduced. Nor is there evidence of

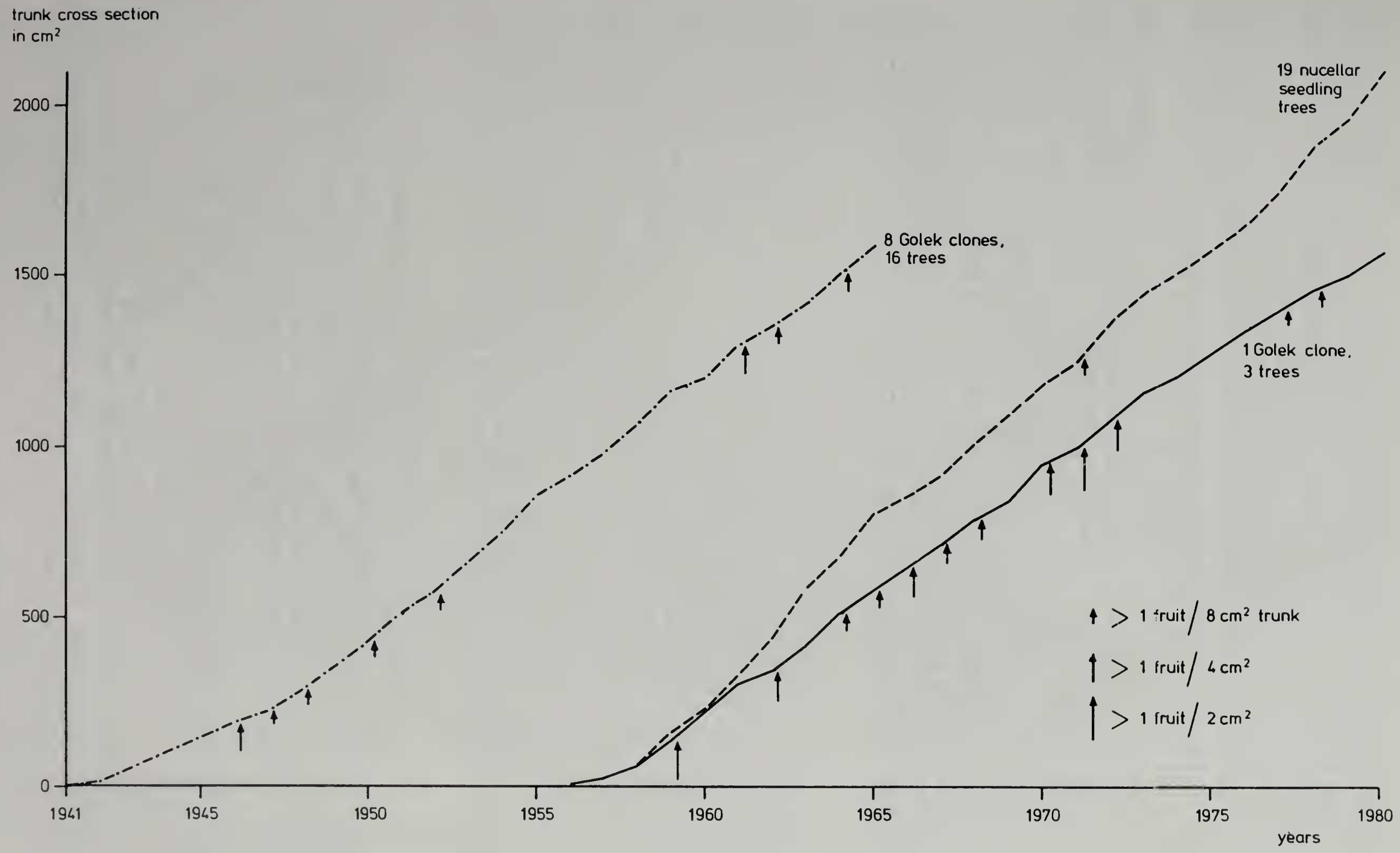

Fig. 1 Growth curves for the 3 groups of 'Golek' trees, and most fruitful years.

biennial bearing. Apparently the yield levels are too low to slow down growth. This even applies to the most fruitful individual 'Golek' trees, which in some years produced about 1 fruit per cm² basal area. Unfortunately trunk girth was measured in August, that is, between bloom and harvest. Consequently the effect of a heavy crop on trunk growth is spread over 2 years and therefore hard to trace.

In Fig. 2 the cumulated numbers of fruit over 15 and 25 years are plotted against basal area at these ages for all 'Golek' trees planted in 1956. The most fruitful trees are those which produce the highest number of fruit in relation to tree size. These trees have been marked by lines linking the values at 15 to 25 years.

This brings five outstanding trees to light: the three trees of clone 35 which stood out in Fig. 1 already, along with two nucellar seedlings of clone 229. These two deviate so much from the unproductive remainder that it is highly improbable that they belong to the same population; they may for instance be sexual instead of nucellar seedlings.

The two superior seedling trees are in league with the grafted trees of clone 35, which between them vary a great deal in size and yield, but form a trio through the parallel course of the lines, indicating that from age 15 to 25 all three trees were equally fruitful. The smallest grafted tree (< 1000 cm² basal area at 25 years) and the one but largest seedling tree (> 2500 cm² basal area) are the two most fruitful trees! After 25 years both trees have borne an aggregate crop of 2.75 fruit per cm² basal area

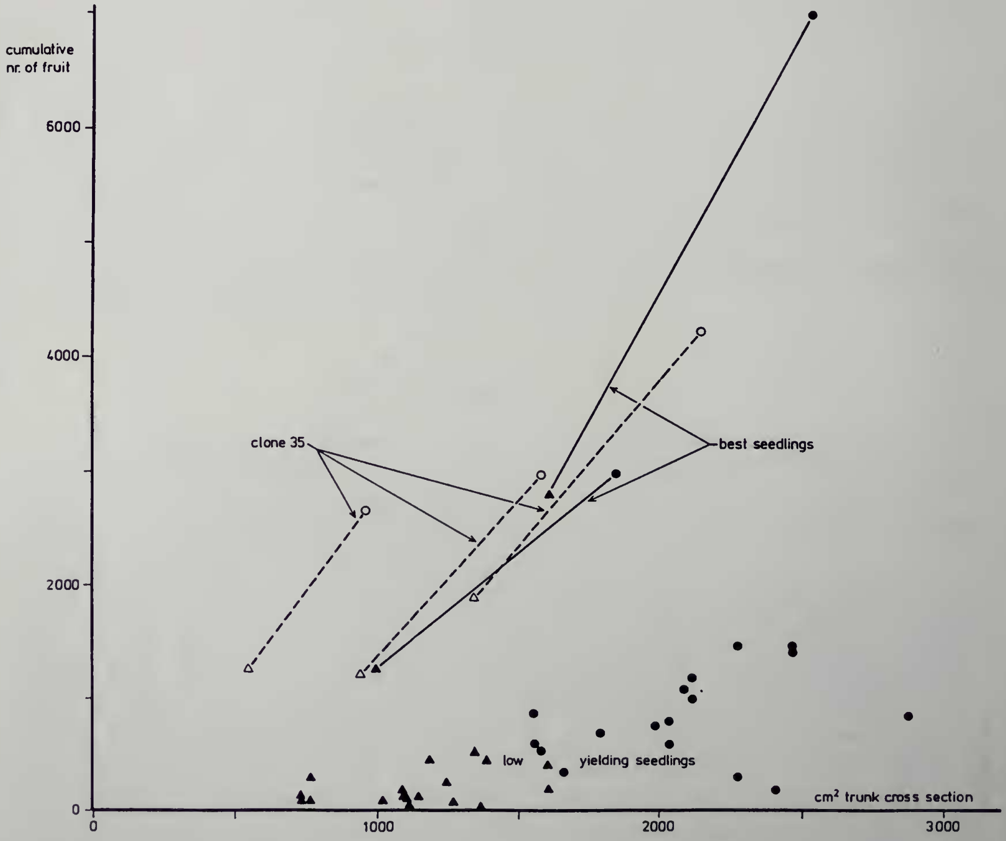

Fig. 2. Cumulative number of fruit against tree size, 15 (△) and 25 (○) years from planting, for each 'Golek' tree planted in 1956. Lines link values at 15 and 25 years for the most fruitful trees.

(although up to the age of 15 years the small tree had done much better than the large one in relation to its size).Planting density of the small tree would have to be nearly 2½ times as high to match the cumulated yield per ha of the large tree at 25 years. The difference in basal area suggests that a 2½-fold increase in number of trees per ha can indeed be accommodated. Higher yields per ha in the early years and easier management of the small trees no doubt would compensate for the cost of the extra trees.

In Fig. 3, growth and yield of all 'Golek' clones on 'Madu' stock are compared at intervals of 6 years.

Since yields in the early years are most important for the grower, the clones in Fig. 3 have been arranged in order of declining yield over the first 18 years; after 12 years the order was almost the same. For all clones planted in 1941 yields during the 13th to 18th year — when the trees should have been at their best — were particularly poor. Consequently the yield picture is largely determined by the crops produced during the last six-year period. Only clone 35 planted in 1956 was most productive in the 13th to 18th year. These trees have borne the largest aggregate crop, not only over 24 years, but throughout. On the other hand, trees of the same clone planted in 1941 produced less than half as much. Because of this large variability which was also found between trees within some of the clones, it is impossible to substantiate the observed differences between the clones.

Looking at the lower half of Fig. 3 it is clear that the differences between clones in the rate of growth were quite large. During the first six years, trees of the most vigorous clone grew three times as fast as trees of the weakest clone; the same holds for the last 6-year interval. However, the clones are not very consistent in their growth rates, so that the differences in tree size after 24 years are not so large. Clone 177 had the largest trees (of similar size as the seedling trees), clone 229 the smallest.

Fig. 3 also shows that there may, after all, be some interaction between tree growth and yield. This is revealed by the drop in tree size ranking with increasing age for the more productive clones on the left hand side, as against rank gains for the least productive clones on the right side. In other words: tree growth of the better yielding clones gradually lags further behind that of the lowest yielding clones. This trend is remarkably consistent. The logical explanation is that fruiting moderates growth, but the reverse — moderate growth promotes fruiting — cannot be ruled out.

Discussion

In retrospect, the experiment was of course premature. The confusion over variations between and within mango cultivars was — and still is — a real problem. However, the role of virus diseases and other endemic infections has to be clarified before clonal selection can make headway. In this respect little progress has been made in the 45 years since the trial started.

The experiment is also much too weak to yield convincing conclusions in respect of the clones. So what is left is a unique long-term record of growth and yield of 'Golek' trees. Unfortunately the yields have been very low, in fact too low to affect growth sufficiently to study the relationships between growth and yield. Administrative problems during wartime and early independence may have left room for pilferage of fruit or casual recording. However, the consistency of the data per tree from year to year suggests that the records are generally sound and that the low yields are real.

The one serious omission is the lack of information on flowering, fruit set and early fruit drop, so that after all these years one can only speculate on the reasons for the poor crops. Probably paucity of bloom and destruction of inflorescences by pests (mango hoppers, tip borers) and diseases (anthracnose) are the main reasons

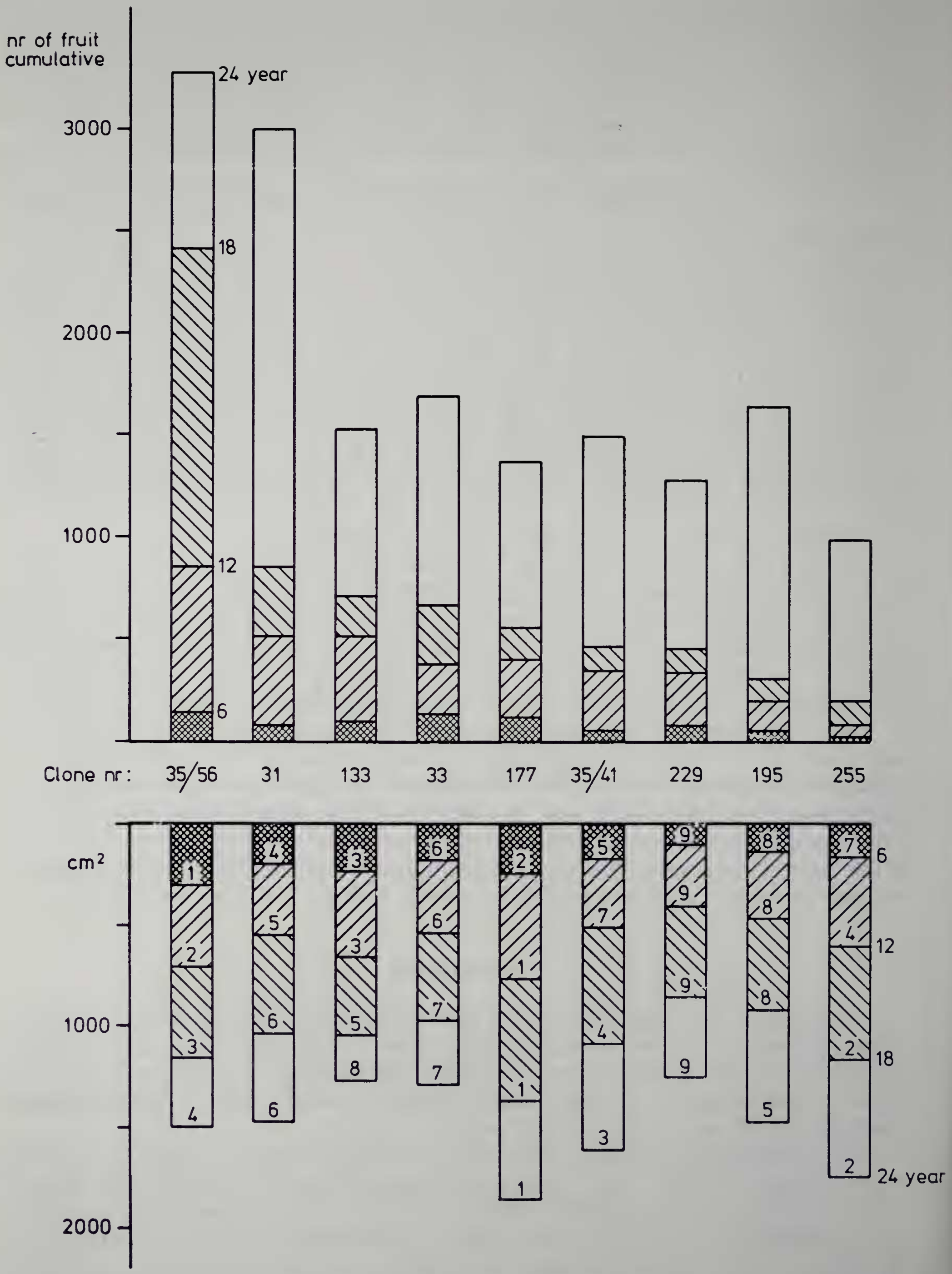

Fig. 3. Growth and yield of 'Golek' clones on 'Madu' stock.
Top: Mean number of fruit per tree, cumulated over 6-year periods.
Bottom: Mean trunk cross section per tree at 6-year intervals; numbers in the columns indicate ranking for tree size: 1 = smallest; 9 = largest.

for crop failure. While gathering the data for this paper in 1983, most inflorescences withered away owing to tip borer damage.

There are indications, at least in some cultivars, that twigs which have flowered will not flower the following year, irrespective of fruit set (Lal Singh and Abdul Aziz Khan, 1939). If this is the case, destruction of a heavy bloom by pests or diseases may therefore decimate the next crop as well as the current crop. Moreover crop failure invites untimely flushing, so that the terminal buds may not be receptive at the time of flower induction in the following year. Verheij and Snijders (1986) describe a similar sequence of events to explain the poor and erratic cropping of clove trees; picking the clove buds also deprives the tree from the stabilizing effect of a load of fruit on the growth rhythm. Current research in Australia aims at solving the riddles posed by erratic flowering in mango (Scholefield, 1983).

The seemingly straight growth curves of the trees probably should be interpreted as having the shape of a flattened S, because that is the common shape of trunk growth curves in forestry. Extending the curves up to the present day (45 years for the 1941 planting!) may settle this point. Westgarth and Buttery (1965) report the results of a spacing experiment with rubber trees over a 30-year period. Converting their girth data into basal area also produces flattened S-curves. The highest growth rates were attained at 5–15 years and ranged from 66 to 14 cm^2 per tree per year for the widest and closest spacings respectively. In comparison the mango growth rates of 90 and 70 cm^2 basal area increments are quite high.

It is concluded that the results of fast-growing, poorly cropping 'Golek' trees form a useful basis of reference, against which improvements in the yield : growth relationship, obtained under more intensive husbandry, can be measured. A further analysis of the Chukurgondang data is recommended, to cover the full 45-year period of recording and to compare growth and yield of 'Golek' with that of other leading cultivars.

Acknowledgements

The Director of the Malang Research Institute for Food Crops, Dr. Soetarjo Brotonegoro, kindly granted permission to use the field records and the Chukurgondang staff have been very hospitable and helpful.

References

Lal Singh and Abdul Aziz Khan, (1939). Relation of growth to fruit bearing in mangoes. *Indian J. Agric. Sci.* 9 (6): 835–867.

Pitoyo, M., Muljono, S. and Schild, D.J., (1982). Survey-inventory and proposals on the upgrading of the sub-station Chukurgondang. Mimeo report, Malang Res. Inst. for Food Crops: 36 p.

Scholefield, P.B., (1983). *Mango research in the northern part of Australia.* Paper presented at International Workshop on Promoting Research on Tropical Fruits, Jakarta, May 30 – June 6. Mimeo. 13 p.

Terra, G.J.A., (1948). Horticulture in: *Agriculture in the Indonesian Archipelago Vol. II.* Ed. Hall, C.J.J. van and Koppel, C. van de. A. van Hoeve, the Hague: 622–746. Dutch.

Verheij, E.W.M., (1972). Competition in apple, as influenced by Alar sprays, fruiting, pruning and tree spacing. *Meded. Landbouwhoge-school Wageningen*, 72–4: 54 p.

Verheij, E.W.M. and C.H.A. Snijders, (1986). *Syzygium aromaticum* (L) Merril and Perry in *Plant resources of South East Asia*; Proposal for a handbook. Eds. Westphal, E. and Jansen, P.C.M. PUDOC, Wageningen: 61–66.

Verheij, E.W.M. and Verwer, F.L.J.A.W. (1972). Yield-density relations for apple trees on a dwarfing and a semi-dwarfing rootstock. *Neth. J. Agric. Sci.* 20: 58–66.

Westgarth, D.R. and Buttery, B.R. (1965). The effect of density of planting on the growth, yield and economic exploitation of *Hevea brasiliensis.* Part 1: The effect on growth and yield. *J. Rubber Res. Inst. Malaysia* 19 (1): 62–73.